Food Chemistry 217 (2017) 266–273

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Nutritional value of duckweeds (Lemnaceae) as human food

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ARTICLE INFO

Article history:
Received 13 June 2016
Received in revised form 23 August 2016
Accepted 28 August 2016
Available online 29 August 2016

Keywords:
duckweed
Landoltia
Lemna
Spirodela
Wolffia
Wolffiella
Proteins
Fatty acids

ABSTRACT

Duckweeds have been consumed as human food since long. Species of the duckweed genera, *Spirodela*, *Landoltia*, *Lemna*, *Wolffiella* and *Wolffia* were analysed for protein, fat, and starch contents as well as their amino acid and fatty acid distribution. Protein content spanned from 20% to 35%, fat from 4% to 7%, and starch from 4% to 10% per dry weight. Interestingly, the amino acid distributions are close to the WHO recommendations, having e.g. 4.8% Lys, 2.7% Met + Cys, and 7.7% Phe + Tyr. The content of polyunsaturated fatty acids was between 48 and 71% and the high content of n3 fatty acids resulted in a favourable n6/n3 ratio of 0.5 or less. The phytosterol content in the fastest growing angiosperm, *W. microscopica*, was 50 mg g^{-1} lipid. However, the content of trace elements can be adjusted by cultivation conditions. Accordingly, *W. hyalina* and *W. microscopica* are recommended for human nutrition.

0. Introduction

Bhanthumnavin and McGarry emphasized already decades ago (Bhanthumnavin & McGarry, 1971) that "Khai-nam", literally meaning "eggs of the water" (duckweed) in Thai language, is "a possible source of inexpensive protein" that can be used as human food. They identified the species as *Wolffia arrhiza* and stressed on their high growth rate. This species is rather rare in Thailand (Landolt, 1986). We investigated three samples of the duckweeds sold in the market for human consumption from Northern Thailand in 2016, and identified all of them as *W. globosa*, which is in accordance with Landolt and Kandeler (1987) suggesting that these authors dealt with the more common species *W. globosa*. Bhanthumnavin and McGarry (1971) measured the protein, carbohydrate, and fat content of these plants and reported that "Khai-nam" was used as food of poor people for many generations in Laos, Thailand and Burma (now Myanmar). In many other South-Asian countries like India, Bangladesh and Pakistan, food is rich in carbohydrates but poor in proteins. Thus, protein-rich duckweed would be a perfect supplement to the rice-based staple food in these countries. Moreover, duckweed might add on to the protein content of the vegetarian or vegan diet as this life style becomes more and more popular in the developed countries.

In their landmark paper, Rusoff, Blakeney, and Culley (1980) investigated four species of duckweeds, *Spirodela polyrhiza*, *Landoltia punctata* (termed as *Spirodela punctata*), *Lemna gibba* and *Wolffia columbiana*, with respect to the protein and fat contents, and the amino acid composition. They already mentioned

Abbreviations: AA, amino acids; AAS, amino acid score; Ala, alanine; ALA, a-linolenic acid; Arg, arginine; Asp, aspartic acid; Cys, cysteine; DW, dry weight; EAA, essential amino acids; EAAI, essential amino acid index; essential AA/non-essential AA, EAA/NEAA; EPA, eicosapentaenoic acid; FA, fatty acids; FAO, Food and Agriculture Organization of the United Nations; FAME, fatty acid methyl esters; Glu, glutamic acid; Gly, glycine; Ile, isoleucine; LA, linoleic acid; LCFA, long-chain fatty acids; LC-PUFA, long-chain polyunsaturated fatty acids; Leu, leucine; Lys, lysine; MCFA, medium chain fatty acids; Met, methionine; MUFA, monounsaturated fatty acids; N, nitrogen; NPN, non-protein nitrogen; Phe, phenylalanine; PUFA, polyunsaturated fatty acids; SCFA, short-chain fatty acids; SD, standard deviation; SDA, stearidonic acid; SFA, saturated fatty acids; Thr, threonine; Trp, tryptophan; Val, valine; WHO, World Health Organization.

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http://dx.doi.org/10.1016/j.foodchem.2016.08.116
0308-8146/